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COMPARISON BETWEEN NON-LINEAR GROWTH MODELS TO DESCRIBE THE GROWTH CURVE IN EGYPTIAN BUFFALO AND CROSSBRED COW CALVES

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ABSTRACT:

The objective of this study was to examine the growth patterns and describe the most suitable growth curve models for buffalo calves and crossbred cow calves in Egypt. A total of 4500 normal records from 150 buffalo calves and 100 crossbred cow calves were examined. The data collected during the period from 2007 to 2010 in a research station which belonging to the Faculty of Agriculture at the University of Alexandria, located approximately 10 km from Alexandria.

The study focused on various fattening performance traits, including Initial Weight, Final Weight, Total Gain, Fattening Period, Average Daily Gain, Feed Intake, and Feed Conversion. The results revealed that buffalo calves exhibited superior performance in terms of average daily gain (0.82 kg/d) and feed conversion (6.53 kg DM/kg gain) compared to crossbred cow calves (0.78 kg/d and 6.77 kg DM/kg gain, respectively).

Furthermore, the study determined that the quadratic and Von-Bertalanffy models were the most suitable for fitting the growth curves of both buffalo calves and crossbred cow calves in the study. These models provided the best fit for describing the growth patterns of the calves under investigation.

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Keywords: Buffalo calves, Crossbred cow calves, Average daily gain, Growth pattern, Growth curve.

INTRODUCTION:

Cows and buffaloes play a crucial role in ensuring food security in Egypt, particularly in the production of red meat for the local market (**Fahim *et al*., 2018**). Growth is commonly defined as the increase in weight over a given period of time (**Brody, 1945**). Growth models serve as a condensed representation of the knowledge required to understand the biological phenomenon of growth, which is essential in beef production systems. Developing a growth model specific to a particular environment and management system can be beneficial in assessing the relative importance of different factors that affect production efficiency (**Menchaca *et al*., 1996**). Various mathematical growth models have been employed to establish growth curves, utilizing different factors that describe growth characteristics. These curves are used to estimate the mature body weight and the rate of weight gain in various animal species. Furthermore, they can be utilized for pre-selecting animals by predicting their future development at any age and determining the optimal timing for slaughter (**Tekel *et al*., 2005**). Understanding the growth pattern is also valuable in devising feeding and management strategies, as well as breeding plans, to enhance overall growth efficiency (**Lambe *et al*., 2006**). Additionally, knowledge about the factors influencing the shape of the growth curve and the relationships among its parameters is necessary for improving its effectiveness (**Morrow *et al*., 1978**). The aims of this research were to examine the growth pattern, describe growth curves using various mathematical models, and identify the most suitable model for buffalo calves and crossbred cow calves in Egypt.

MATERIALS AND METHODS:

Data and Management:

During the period from 2007 to 2010, a total of 4500 normal records were analyzed, comprising 150 buffalo calves and 100 crossbred cow calves. The data was collected from the research station located 10

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kilometers away from Alexandria, which belongs to the Faculty of Agriculture at the University of Alexandria.

The calves were kept in semi-open shed yards where they had unrestricted movement. Each yard housed a group of calves with similar average body weights. Their diet consisted of a mixture of corn silage and concentrate ration, following the TMR (Total Mixed Ration) system, which was adjusted based on their body weights according to the guidelines provided by the National Research Council (**NRC, 2001**). Ample water was available to the animals at all times. The calves exhibited a healthy appearance and showed no signs of diseases or ailments.

On a monthly basis, the calves were weighed after a 16-hour fasting period. The weights of the animals were recorded, and the feed intake was measured and estimated for each calf in terms of kilogram dry matter. The feed conversion rate was calculated by determining the amount of kilogram dry matter intake required for a one-kilogram gain in body weight.

The performance traits under study were: Initial Weight (kg), Final Weight (kg), Total Gain (kg), Fattening Period (mo), Average Daily Gain (kg/d), Feed Intake (kg DM/d) and Feed Conversion (kg DM/kg gain).

Statistical Analysis:

The normality of the data was assessed using the Shapiro-Wilk test, conducted through the UNIVARIATE procedure (**SAS, 2004**). The results of the test indicated that all the data followed a normal distribution [Shapiro-Wilk test (W) $\geq$ 0.90]. Data of performance were analyzed using GLM procedure (SAS, 2004) according to the following model:

$$\mathbf{Y_{ij} = \mu + T_i + e_{ij}}$$

Where: $\mathbf{Y_{ij}}$ = any of the performance trait, $\boldsymbol{\mu}$ = the overall mean, $\mathbf{T_i}$ = fixed effect of i^{ed} species, and $\mathbf{e_{ij}}$= the residual error. To test for significant differences among means, the least significant difference ($LSD_{0.05}$) was used.

Growth pattern and Growth curve:

Buffalo calves and crossbred cow calves in the present study were weighed monthly from the first month to 18th month of age (30 – 540 d).

The growth was measured by some growth parameters on basis of animal weight and determining feed conversion and changing body weight by age. The growth parameters used as measures of body weight changes were as the following:

- Average absolute growth rate = $W_2 – W_1 / t_2 – t_1$
- Minot's average relative growth rate = $(W_2-W_1/t_2-t_1) / W_1$
- Minot's average percentage growth rate = Minot's average relative growth rate X 100
- Brody's average relative growth rate = $[(W_2-W_1)/(t_2-t_1)] / [(w_1+w_2)/2]$
- Brody's average percentage growth rate = Brody's average relative growth rate X 100
- Instantaneous growth rate = $\text{Ln } W_2 – \text{Ln } W_1 / t_2-t_1$

Where: W_1 and W_2 are two consequently weights and t_1 and t_2 are the times in days which the weights of W_1 and W_2 were recorded.

The relationships between ages and weights were examined using linear and quadratic equations. Furthermore, four modified nonlinear growth functions were fitted to the data of each calf using the NLIN procedure in **SAS (2004)**. The models used for fitting the data were the Brody model (**Brody, 1945**), the Gompertz model (**Laird, 1965**), the Von-Bertalanffy model (**Von Bertalanffy, 1957**), and the logistic model (**Nelder, 1961**).

Various parameters were calculated to evaluate and compare the models in terms of their fit accuracy. These parameters included the individual determination coefficient (R^2), the root of residual mean square error (RMSE), the Durbin-Watson coefficient (DW), and the Akaike's information criteria (AIC) values (Table 1). The AIC values, determined by the log-likelihood and the number of estimated parameters, serve as an indicator of the model's goodness-of-fit and the effectiveness of incorporating additional parameters (**Akaike, 1974**).

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Table 1. Linear and non-linear functions used to describe the growth curves and goodness of fit equations.

Model	Equation[1]
Brody	$y = a\,(1 - be^{-ct})$
Gompertz	$y = a \exp(- be^{-ct})$
Von-Bertalanffy	$y = a\,(1 - be^{-ct})^3$
Logistic	$y = a / (1 + be^{-ct})$
Quadratic	$y = a + bt + ct^2$
Linear	$y = a + bt$
Parameters of accuracy:	**Equation[2]**
Determination coefficient (R^2)	(1-(SSE / SST))* 100
Akaike's information criteria (AIC)	-2 log L + 2 K
Root mean squares errors (RMSE)	$\frac{1}{n}\sum_{i=1}^{n}(y_i - \hat{y}_i)^2$
Durbin-Watson coefficient (DW)	$\frac{\sum_t^n (e_t - e_{t-1})^2}{\sum_{t=1}^n e_t^2}$

[1]y represents body weight at age t; a represents asymptotic weight, b is an integration constant related to initial animal weight, c is the maturation rate and t is the age in day.

[2]SSE is sum square of error and SST is total sum of square, K is the number of estimated parameters in the model but L is the maximized value of the likelihood function for the estimated model, y_i are the actual values and $\hat{y}_i$ are values predicted by the regression model and e_t is residual at time e, e_{t-1} is residual at time $t-1$.

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RESULTS AND DISCUSSION:

Averages of fattening performance traits:

Table 2 presents the average values of fattening performance traits for the animals under study. The initial weight mean for buffalo calves was 38.52 kg, while the final weight mean was 483.48 kg. Over a period of 18 months, the buffalo calves achieved a total body gain of 444.96 kg. On average, each buffalo calf consumed 5.38 kg of dry matter intake per day and gained 0.82 kg in body mass daily. The feed conversion rate for buffalo calves was calculated to be 6.53 kg of dry matter intake for every 1 kg of body weight gain.

In contrast, the initial weight mean for crossbred cow calves was 53.19 kg, and the final weight mean was 471.69 kg. These calves experienced a total body gain of 418.50 kg over a period of 18 months. The average daily dry matter intake for each crossbred cow calf was 5.25 kg, and they gained 0.78 kg daily in body mass. The feed conversion rate for crossbred cow calves was determined to be 6.77 kg of dry matter intake for each 1 kg of body weight gain.

The average daily gain of buffalo calves in the present study was found to be higher than the results reported by **Abd El-Aziz (2002)**, who observed a growth rate of 0.778 kg/day for buffalo calves. However, our findings were lower than those reported by **Zeidan *et al*. (2003)**, who documented a growth rate of 0.866 kg/day for male buffalo calves.

Additionally, the average daily gain of crossbred cow calves in our study was higher than the result reported by **Fouad (2001)**, who found an average daily gain of 0.683 kg/day for Baladi cow calves. However, it was lower than the values reported by **Marghany (2007)** and **Abd El-Rahman (2008)** for Friesian crossbred male calves. Marghany reported a growth rate of 0.854 kg/day, while Abd El-Rahman documented growth rates ranging from 1.260 to 1.460 kg/day.

In general, buffalo calves achieved the best performance for average daily gain and feed conversion compared to crossbred cow calves under study.

Table 2. Least squares means of fattening performance traits for studied animals.

Trait	Buffalo Calves	Crossbred Cow Calves	*P*-value
No.	150	100	-
Initial Weight, kg	$38.52^{b}\pm2.04$	$53.19^{a}\pm3.87$	0.01
Final Weight, kg	$483.48^{a}\pm14.33$	$471.69^{b}\pm12.65$	0.01
Total Gain, kg	$444.96^{a}\pm13.89$	$418.50^{b}\pm11.97$	0.01
Experimental Period, mo	18	18	-
Average Daily Gain, kg/d	$0.82^{a}\pm0.01$	$0.78^{b}\pm0.01$	0.01
Feed Intake, kg DM/d	5.38±0.04	5.25±0.03	0.06
Feed Conversion, kg DM/kg gain	6.53±0.14	6.77±0.13	0.06

Growth pattern

Tables 3 and 4 present a summary of the average body weight and growth patterns based on age in days for both buffalo calves and crossbred cow calves in the study. The growth patterns calculated in this study include the average growth rate or daily gain, Minot's average relative and percentage growth rate, Brody's average relative and percentage growth rate, and the instantaneous relative growth rate. These measurements were used to assess and describe the body growth at all stages of the age range studied.

Growth rate or Average daily gain (ADG)

The results presented in Table 3 indicate that the average daily gain (ADG) of buffalo calves tended to be 1 kg or higher after the weaning stage, specifically between 120 and 360 days of age. However, the ADG showed fluctuation and an inconsistent trend before eventually decreasing to below 1 kg. It was observed that the weight of buffalo calves reached 374 kg at 360 days (12 months) of age, and it increased to 459 kg at 450 days (15 months), which could be considered as the endpoint of the fattening process for economic purposes. **El-Attar *et al*. (2017)** recorded that the best average daily gain in the period from 150 to 240 day which was 1.228 kg/day and 1.042 kg/day, respectively in fattening male Egyptian buffalo calves.

The highest daily gain was recorded at 244 days (1.124 kg/d) and 270 days (1.120 kg/d), corresponding to the initial stage of the growth curve where growth rate is rapidly increasing. This period is considered suitable for the fattening process. Additionally, the age range of 300-390 days (10-13 months) appeared to represent the sexual puberty stage of buffalo calves.

On the other hand, the early stage of age (birth to 3 months) exhibited the lowest daily gain. This can be attributed to the fact that buffalo calves during this period primarily rely on the suckling system, and the main objective is to ensure their survival and health until the time of weaning.

According to the data presented in Table 4 for crossbred cow calves, it was observed that the average daily gain (ADG) exceeded 1 kg per day between 60 and 300 days (2 to 10 months) of age. Subsequently, the ADG gradually declined and remained below 1 kg per day. The highest ADG values were recorded at 150 and 180 days of age, reaching 1.285 and 1.288 kg per day, respectively. Additionally, the age range of 270-300 days (9-10 months) appeared to coincide with the onset of sexual puberty in crossbred cow calves, as evident from the changes in ADG during this period. The weight of 373 kg at 10 months of age seemed to represent the threshold for concluding the fattening process in terms of economic viability. **Hassan (1999)** reported that, the average growth rate of Baladi calves was over 1 Kg/day during the first four months of fattening then a sharp decrease in growth rate occurred during the following months.

In general, it can be concluded that initiating the fattening process after the weaning stage, around 60 days of age, for crossbred cow calves, and after approximately 120 days of age for buffalo calves, allows for capitalizing on their higher daily gain during this period while minimizing feeding costs due to lower feed intake. This approach ensures a more economically feasible fattening process.

In summary, the optimal timing for starting the fattening process is after weaning, around 60 days for crossbred cow calves and 120 days for buffalo calves. This strategic timing allows for maximizing the higher daily gain observed during this period while minimizing feeding costs due to lower feed intake. As a result, it ensures an economically advantageous fattening process.

Minot's and Brody's growth rates

The Average Daily Gain (ADG) can be influenced by the initial weight and final weight, particularly when there is a longer time gap between the two measurements. To counteract this potential impact, one can employ Minot's relative or percentage growth rate to eliminate the influence of the initial weight. Alternatively, Brody's relative or percentage growth rate can be utilized to account for both the initial and final weights. These alternative growth rates help mitigate the effects of the weights on ADG.

According to the data in Table 3, it was observed that Minot's percentage growth rates and Brody's percentage growth rates ranged from 1.868 to 0.536% and from 1.459 to 0.496% respectively, at the age of 60 to 240 days. After that point, both growth rates rapidly decreased. The highest values were recorded during the early stage of age (60 - 120 days) because it corresponded to the smallest initial weights, and the body daily gains increased during this period. As the age progressed, Minot's values tended to decrease due to the increasing initial weight, particularly at later ages, resulting in lower values. This trend continued after reaching the age of 240 days (8 months).

Table 4 presents the growth rates of crossbred cow calves, where Minot's growth rates ranged from 1.919 to 0.543% and Brody's growth rates ranged from 1.490 to 0.502% during the age period of 60 to 210 days. Subsequently, both growth rates exhibited a rapid decrease. This decline can be attributed to the progression of both initial and final weights, as they increased in value. According to our results, the body weight of calves tended to increase with increasing rate hence with decreasing rate by age and weight. Our results were similar than the results obtained by **Lawrence *et al.*, (2012)**. Consequently, the early stages of age were crucial for the fattening process, as they allowed for the utilization of the highest growth rates.

Instantaneous relative growth rates

This parameter represents the percentage increase in body weight relative to a specific age. In both buffalo calves (Table 3) and crossbred cow calves (Table 4), it was observed that the values of instantaneous relative growth rates gradually decreased with increasing weight and age until reaching 240 days of age in buffalo calves and 210 days of age in crossbred cow calves. After these points, the growth rates experienced a rapid decline. This indicates that the early stages of age were crucial for the fattening process because the calves were younger and lighter, exhibiting the highest growth rates. This highlights the economic advantage of focusing on fattening during these early stages.

Table 3. Growth pattern of buffalo calves under study.

Age, d	Weight, kg	Growth pattern					
		ADG	Minot	Minot %	Brody	Brody %	Instant
30	38	-	-	-	-	-	-
60	60	0.713	0.0187	1.868	0.0146	1.459	0.0148
90	85	0.843	0.0142	1.416	0.0117	1.168	0.0118
120	113	0.948	0.0112	1.117	0.0096	0.956	0.0096
150	144	1.026	0.0091	0.906	0.0080	0.797	0.0080
180	177	1.080	0.0075	0.750	0.0067	0.674	0.0068
210	210	1.112	0.0063	0.630	0.0058	0.575	0.0058
240	244	1.124	0.0054	0.536	0.0050	0.496	0.0050
270	277	1.120	0.0046	0.460	0.0043	0.430	0.0043
300	310	1.103	0.0040	0.398	0.0038	0.376	0.0038
330	343	1.075	0.0035	0.347	0.0033	0.329	0.0033
360	374	1.039	0.0030	0.303	0.0029	0.290	0.0029
390	404	0.997	0.0027	0.267	0.0026	0.257	0.0026
420	432	0.951	0.0024	0.236	0.0023	0.228	0.0023
450	459	0.902	0.0021	0.209	0.0020	0.202	0.0020
480	485	0.851	0.0019	0.185	0.0018	0.180	0.0018
510	509	0.800	0.0017	0.165	0.0016	0.161	0.0016
540	531	0.749	0.0015	0.147	0.0014	0.144	0.0014

Table 4. Growth pattern of crossbred cow calves under study.

Age, d	Weight, kg	Growth pattern					
		ADG	Minot	Minot %	Brody	Brody %	Instant
30	53	-	-	-	-	-	-
60	83	1.011	0.0192	1.919	0.0149	1.490	0.0152
90	118	1.154	0.0139	1.391	0.0115	1.151	0.0116
120	155	1.243	0.0106	1.057	0.0091	0.912	0.0092
150	193	1.285	0.0083	0.829	0.0074	0.738	0.0074
180	232	1.288	0.0067	0.666	0.0061	0.605	0.0061
210	270	1.260	0.0054	0.543	0.0050	0.502	0.0050
240	306	1.211	0.0045	0.449	0.0042	0.420	0.0042
270	341	1.147	0.0037	0.374	0.0035	0.355	0.0035
300	373	1.073	0.0031	0.315	0.0030	0.301	0.0030
330	403	0.994	0.0027	0.267	0.0026	0.256	0.0026
360	430	0.914	0.0023	0.227	0.0022	0.219	0.0022
390	455	0.834	0.0019	0.194	0.0019	0.188	0.0019
420	478	0.757	0.0017	0.166	0.0016	0.162	0.0016
450	498	0.684	0.0014	0.143	0.0014	0.140	0.0014
480	517	0.615	0.0012	0.123	0.0012	0.121	0.0012
510	533	0.551	0.0011	0.107	0.0010	0.105	0.0011
540	548	0.493	0.0009	0.092	0.0009	0.091	0.0009

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Growth Curve

Table 5 presents the average parameter estimates (a, b, k) for the growth curve of linear and non-linear models, along with goodness-of-fit indicators for each growth model. The included indicators are coefficients of determination (R^2), Akaike's information criteria (AIC), root mean square error (RMSE), and the Durbin-Watson coefficient (DW). These indicators provide measures of how well the growth models fit the data for both buffalo calves and crossbred cow calves.

In the case of buffalo calves, the Brody and Gompertz models exhibited high estimates for parameter a, with Brody at 298.4 and Gompertz at 298.4, while the quadratic model showed the smallest estimate of -38.0. For parameter b, the Brody model had the highest estimate of 421480, followed by the Gompertz model at 237700, and the linear model had the lowest estimate of 1.06. The estimated parameter k was close to one for the Gompertz model (0.8781), followed by the Brody model (0.4970). However, it was very low for the Quadratic (-0.0003), Von-Bertalanffy (0.001), and Logistic (0.005) models. The Quadratic and Von-Bertalanffy functions demonstrated the best overall fit, as they had high R^2 estimates of 0.991 and 0.992, respectively. The Logistic and Linear functions also performed well, with an R^2 estimate of 0.989.

While the R^2 values did not show significant differences to determine the best fit function, the root mean square error (RMSE) values provided more discriminatory information. Among the models, the Von-Bertalanffy, Logistic and Linear functions had the smallest RMSE values, with values of 9.01, 10.06, and 10.59, respectively. Additionally, the Akaike's information criteria (AIC) values for the Von-Bertalanffy and Quadratic models were 30091 and 30427, respectively.

Most of the Durbin-Watson coefficients were close to two, indicating the absence of autocorrelation in the data. Based on these findings, the Quadratic and Von-Bertalanffy models emerged as the best models to fit the growth curve for buffalo calves. Figure 1 presents the growth curves for the two best-fitting models.

In the case of crossbred cow calves, the Von-Bertalanffy and Logistic models exhibited high estimates for parameter a, with Von-

Bertalanffy at 660.7 and Logistic at 535, while the quadratic model showed the smallest estimate of -37.7. For parameter b, the Gompertz model had the highest estimate of 43.75, followed by the Logistic model at 7.09, and the Brody model had the lowest estimate of -86490. The estimated parameter k was highest for the Brody model at 1279196, nearly zero for the Von-Bertalanffy and Logistic models (0.0044 and 0.0093, respectively), and very low for the Quadratic (-0.0011), Von-Bertalanffy (0.001), and Logistic (0.005) models.

The Von-Bertalanffy and Quadratic functions demonstrated the best overall fit for the growth curve of crossbred cow calves, with high R^2 estimates of 0.983 and 0.984, respectively. They were followed by the Logistic and Linear functions, with R^2 estimates of 0.980 and 0.979, respectively. However, the R^2 values did not significantly differentiate the best-fit function. The Von-Bertalanffy and Logistic models had the smallest root mean square errors (8.66 and 8.67, respectively), indicating better fit compared to other models. Additionally, the Akaike's information criteria (AIC) values for the Von-Bertalanffy and Quadratic models were 27618 and 27620, respectively.

Based on these findings, the Von-Bertalanffy and Quadratic models provided the best fit for the growth curve of crossbred cow calves.

Our results agreed with the results obtained by **Topal *et al.* (2004)** who reported that the Von-Bertalanffy function was the best fit for Awassi sheep breed. Similarly, **Freitas (2005)** showed that Von-Bertalanffy function was more versatile to fit growth curves in sheep. In the same trend, **Malhado *et al.* (2017)** obtained a higher efficiency of the Bertalanffy function to fit growth curves in Murrah, Jaffarabadi and Mediterranean buffaloes.

Most of the Durbin-Watson coefficients were close to two, indicating the absence of autocorrelation in the data. Therefore, the Quadratic and Von-Bertalanffy models were deemed the best models to fit the growth curve for buffalo calves. Figure 2 presents the growth curves for these two best-fitting models.

The Richards model was problematic during convergence and, therefore, did not fit the data sets under study.

On the other hand, **Brown *et al.* (1976)** conducted a study using a similar approach to evaluate the fit of five functions applied to beef cattle data from two locations. Their findings indicated that both the Brody and Richards functions provided a good fit to the data, while the Logistic function demonstrated a poor fit. It's worth noting that various nonlinear growth models are available for mathematically describing growth curves, as mentioned by **Matthes *et al.* (1996).** However, among the different species, the Gompertz function is commonly used (**Meyer, 1995; Nešetřilová *et al.*, 1999**).

Also, **Forni *et al.* (2009)** compared several nonlinear functions for describing the growth curves of females cattle Nelore and found that Brody model was the most adequate in describing the growth curve as compared with Gompertz, Logistic and Bertalanffy models. In contrast of our results**, Salem *et al.* (2013)** confirmed that the Brody model was the best to describe the growth curve when fattening Friesian crossbred and Buffalo male calves.

Similarly, **Lopes *et al.* (2016)** and **Moreira *et al.* (2016)** found that the Brody function is the most suitable for the study of growth in Nellore Mocho and Caracu cattle, respectively. In the same trend, **Goldberg and Ravagnolo (2015)** concluded that the Richards function fitted the data better than the Brody, Bertalanffy or Gompertz models in Angus beef cattle. Also, **Agudelo-Gómez *et al.* (2009)** and **Araújo *et al.* (2012)** found that the Brody and Gompertz models as the best fitting in buffaloes, respectively.

Based on the obtained results, it can be concluded that the Quadratic function was the most suitable model for predicting the growth in both buffalo calves and crossbred cow calves. This conclusion is supported by several factors: the Quadratic model exhibited the highest R^2 value, indicating a strong fit to the data, and lower values of RMSE and AIC compared to other non-linear regression models. Similarly, the Von-Bertalanffy growth model also showed good performance in explaining the relationship between weight and age, reflecting the growth development of both buffalo calves and crossbred cow calves.

In conclusion, by utilizing the Quadratic growth model and the Von-Bertalanffy growth model, accurate predictions of growth can be made, enabling the determination of optimal feeding regimes, maturity age, identification of growth and development issues over time, and even determining the best time for sale. These models provide valuable insights into managing the growth and development of both buffalo calves and crossbred cow calves based on their body weight-age data.

Table 5. Growth curve parameters and fitting of buffalo calves and crossbred cow calves.

Equations	A	b	k	MSE	RMSE	AIC	DW	R^2
Buffalo Calves								
Brody	298.4	421480	0.4970	9575.00	97.85	49929	0.66	0.004
Gompertz	298.4	237700	0.8781	9575.00	97.85	49929	0.66	0.004
Von-Bertalanffy	791.2	0.70	0.0032	81.19	9.01	30091	1.82	0.992
Logistic	578.6	9.89	0.0081	101.25	10.06	31009	1.61	0.989
Quadratic	-38.0	1.26	-0.0003	88.02	99.38	30427	1.71	0.991
Linear	-10.6	1.06	-	101.18	10.59	31006	1.52	0.989
Crossbred cow calves								
Brody	299.4	-86490	1279196	4608	67.88	43505	0.82	0.000
Gompertz	361.0	43.75	0.5700	4608	67.88	43505	0.82	0.000
Von-Bertalanffy	660.7	0.65	0.0044	75.07	8.66	27618	1.80	0.983
Logistic	535.4	7.09	0.0093	78.46	8.85	27788	1.79	0.980
Quadratic	-37.7	1.68	-0.0011	75.12	8.67	27620	1.79	0.984
Linear	28.7	1.13	-	98.28	9.91	28657	1.49	0.979

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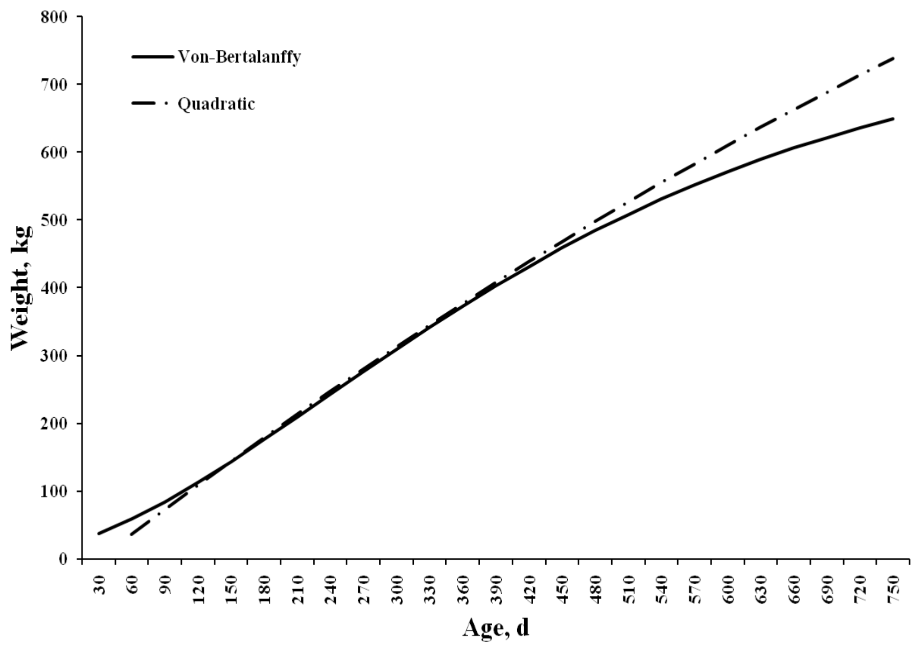

Figure 1. Estimated growth curves as a function of age obtained from the quadratic and Von-Bertalanffy models in buffalo calves.

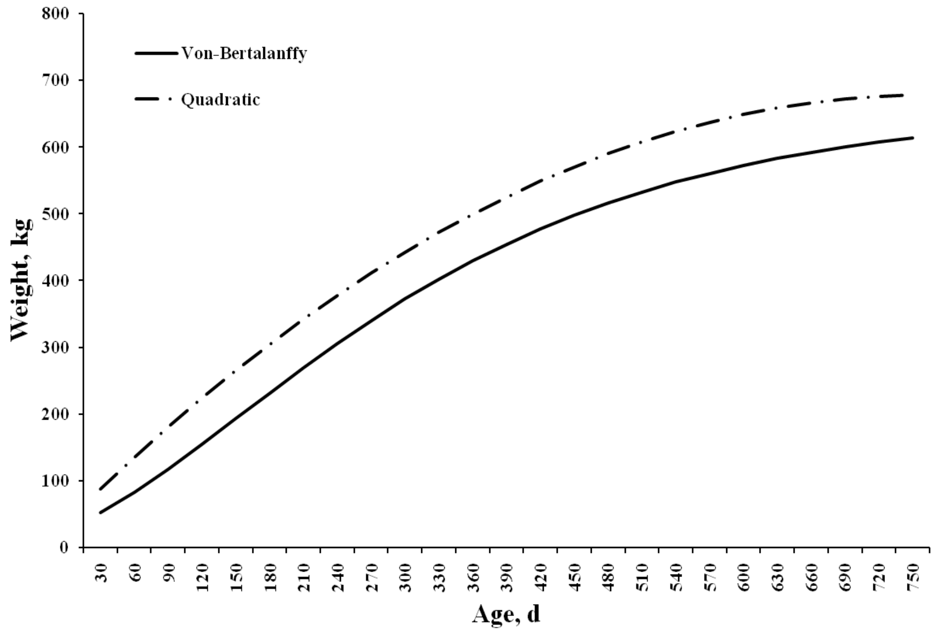

Figure 2. Estimated growth curves as a function of age obtained from the quadratic and Von-Bertalanffy models in crossbred cow calves.

CONCLUSION

Buffalo calves achieved the best performance for average daily gain and feed conversion compared to crossbred cow calves under study. Furthermore, the Quadratic and Von-Bertalanffy models were identified as the best models for fitting the growth curve of both buffalo calves and crossbred cow calves in the study.

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مقارنة بين نماذج المعادلات الغير خطية لوصف منحنيات النمو فى عجول الجاموس المصرى وعجول الأبقار الخليطة

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الملخص العربى:

كان الهدف من هذه الدراسة هو فحص أنماط النمو ووصف أنسب نماذج منحنى النمو لعجول الجاموس المصرى وعجول الأبقار الخليطة في مصر. تم فحص إجمالي 4500 سجل لـ 150 عجول جاموس مصرى و100 عجول أبقار خليطة. تم جمع البيانات خلال الفترة من 2007 إلى 2010 في محطة البحوث التابعة لكلية الزراعة بجامعة الإسكندرية والواقعة على بعد حوالي 10 كم من مدينة الإسكندرية.

ركزت الدراسة على صفات أداء التسمين المختلفة بما في ذلك الوزن الأولي، الوزن النهائي، الوزن المكتسب، فترة التسمين، متوسط النمو اليومي، كمية العلف المأكول، معدل التحويل الغذائى. أوضحت النتائج أن عجول الجاموس أظهرت أداءا متفوقًا من حيث متوسط النمو اليومي (0.82 كجم/يوم) ومعدل التحويل الغذائى (6.53 كجم مادة جافة/كجم وزن مكتسب) مقارنة بعجول الأبقار الخليطة (0.78 كجم/يوم ، 6.77 كجم مادة جافة/كجم وزن مكتسب على التوالى). علاوة على ذلك، حددت الدراسة أن نموذج Quadratic ونموذج Von-Bertalanffy كانا الأكثر ملاءمة فى منحنيات النمو لكل من عجول الجاموس المصرى وعجول الأبقار الخليطة في الدراسة ، كما قدمت هذه النماذج الأنسب لوصف أنماط نمو العجول تحت الدراسة.